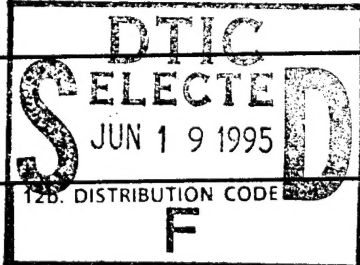


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13. ABSTRACT (Maximum 200 words) Eight years ago the AFOSR awarded us a grant to study the solar activity cycle both to understand its physical nature, and to forecast the timing and magnitude of future maxima with as much anticipation as possible. Because solar activity affects so many processes on Earth, from the reliability of solid state components on satellites, to electric power grids, to the orbital lifetime of low Earth orbit satellites, etc., such information is important to the DoD in general, and to the USAF in particular. The specific components of this study were three different tasks. The first consisted in developing an empirical forecasting scheme based on general but sound physical principles whose only objective was to provide the timing and magnitude of the following activity maximum both half a cycle and, hopefully, one and a half cycle in advance. The second task involved a realistic modeling of the magnetized flow in the solar convective envelope with the ultimate objective of producing a dynamo model sufficiently solid to allow detailed forecasting of the behavior of future cycles. The third task involved partial support for the development of the Solar Disk Sextant, a space-borne experiment which measures variations of the size and shape of the Sun with milli arc s				
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FINAL REPORT

Grant No.: AFOSR-91-0053
Title: Development of a System for Accurate Forecasting of Solar Activity
Institution: Department of Astronomy, Yale University
P.I.: Sabatino Sofia

I. BACKGROUND

Eight years ago the AFOSR awarded us a grant to study the solar activity cycle both to understand its physical nature, and to forecast the timing and magnitude of future maxima with as much anticipation as possible. Because solar activity affects so many processes on Earth, from the reliability of solid state components on satellites, to electric power grids, to the orbital lifetime of low Earth orbit satellites, etc., such information is important to the DoD in general, and to the USAF in particular. The specific components of this study were three different tasks. The first consisted in developing an empirical forecasting scheme based on general but sound physical principles whose only objective was to provide the timing and magnitude of the following activity maximum both half a cycle and, hopefully, one and a half cycle in advance. The second task involved a realistic modeling of the magnetized flow in the solar convective envelope with the ultimate objective of producing a dynamo model sufficiently solid to allow detailed forecasting of the behavior of future cycles. The third task involved partial support for the development of the Solar Disk Sextant, a space-borne experiment which measures variations of the size and shape of the Sun with milli arc s accuracy. This experiment, among other objectives, can test the detailed models of flow and/or dynamo. Considerable advances were made in all of the tasks, as detailed hereafter.

II. ACCOMPLISHMENTS

a) In the first task we have been remarkably successful in producing an empirical forecasting scheme which can give the time (1) and magnitude (2) of a given cycle maximum from observations taken at the preceding minimum. The forecast of the size and timing of cycle 22 was as remarkably accurate as it was different from other prognostics. We forecast the second largest cycle ever at a time when most forecasters expected it to be a very small cycle. However, as the rise to maximum started with a very steep slope, many changed their forecast for cycle 22 to become the largest ever. As it turned out, the maximum happened early (as we had forecasted), and it was the second largest ever. On the other hand we have so far been singularly unsuccessful at using any of the features of the extended activity cycle to allow the forecasting at an earlier time (3). and at the present time we are testing a scheme for long-term forecasting based on general properties of the solar magnetic field (4). We are getting a clearer feeling of precisely what can we forecast and what we cannot for longer timescales by further examining a broader set of observations to search for the "magic bullet" to unravel this issue.

b) In the second task, which involves extensive numerical models of 3D magnetized flows, and which requires considerable supercomputer time, we have also made significant inroads, although we are not as close to the end as we wish. We have been able to model

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fully compressible outer solar envelope, including magnetic field, in 3D (5). Because this modeling is done under the Large Eddy Simulation (LES) approach, it is necessary to have a valid model of the sub-grid scale magnetic conductivity, which did not exist at the beginning of our work. We developed such a model, and subjected it to extensive testing (6). Having completed producing the key elements of the problem, we are now ready to put them together to build a numerical "dynamo". Since the principal contributor to this effort, Dr. Peter Fox, left Yale to join the High Altitude Observatory of NCAR, continuing this very demanding task has become much simpler for us. Dr. Fox's salary is fully funded by NCAR, and his access to outstanding computational facilities is assured. This allows us to continue the work.

c) Regarding the SDS, the concept has been fully proven. A balloon-borne version of the instrument exists (7,8,9), which has demonstrated its design capabilities on measurements carried on balloon flights carried out in September 1992, and September 1994. Although the principal objectives of the experiment address changes of the diameter and oblateness, and the required instrumental configuration has only existed for one flight, an important result of the experiment has already been produced by disproving a variability of the oblateness suggested in recent publications. Since the main objectives of the experiment require to continue flights for at least a decade, support for these flights was sought and has been secured from NSF and NASA. We have most of the required funds for the next 3 years. More recently, we have submitted a proposal to the Academic Research Infrastructure program at NSF to obtain funding to build a second version of the experiment for a long duration flight from the Arctic circle in Summer 1996.

In summary, we feel that the work sponsored by this grant was very successful, by completing most of the tasks described in our proposal, and also by making substantial advances in areas not anticipated there.

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